EFFECT OF VARYING SPEED
UPON THE GAS CONSUMPTION OF THE WESTINGHOUSE GAS ENGINE

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OF THE

WESTINGHOUSE GAS ENGINE

A THESIS

PRESENTED BY

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TO THE

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EXPERIMENTS ON WESTINGHOUSE GAS ENGINE.

These experiments were performed for the purpose of determining the effects of varying speed upon the gas consumption of the Westinghouse Gas Engine.

The gas engine used was a three-cylinder 8 x 10 vertical engine, installed at the Armour Institute of Technology for experimental purposes. It is single acting and of the four-cycle type with cranks set at 120 degrees apart, and is rated at 40 H.P. when running at 325 R.p.m.

Practically all the working parts of the engine, except the pistons and valves, are enclosed in a one-piece cast iron housing, which not only serves as a rigid support for the cylinders and main crank shaft, but also contains a heavy mineral oil which serves to lubricate the internal parts. This automatic lubrication is accomplished by means of the crank and connecting rods dipping successively into the oil and thus causing it to splash over the journals and cylinder walls.

The cylinders are independent of each other and are bolted on the top of the crank case. The cylinder walls, jacket, combustion chamber, and exhaust

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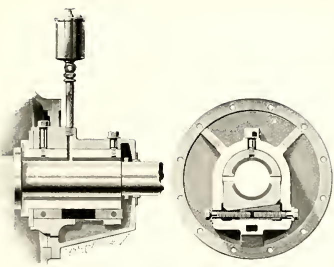


MAIN BEARING

passages are all cast together, the jacket walls, however, are cast separate from the cylinder walls at the lower end.

On each side of the crank case are bolted three 12" x 15" cover plates, one being opposite each crank, thus giving sufficient access to all the interior working parts. At each end of the crank case are two large openings; to the castings of which are bolted the main bearing supports.

BEARINGS.

Each bearing consists of a two-part babitted shell arranged for vertical adjustment by wedges and draw bolts. The wear of the main bearings is always downward, and consequently by means of this arrangement the shaft can always be restored to its original distance from the base of the engine; this not only maintains a constant volume in the clearance between the pistons and cylinder heads, thus maintaining a constant degree of compression, but also keeps the shaft in proper alignment with the bearings of any direct-connected machine. There are two internal bearings which are very simple in construction and are adjustable in the same manner as the main bearings.

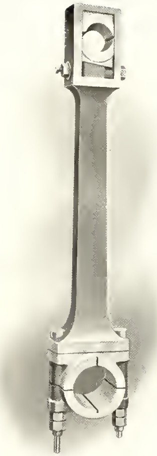


Fig. 8. Connecting Rod

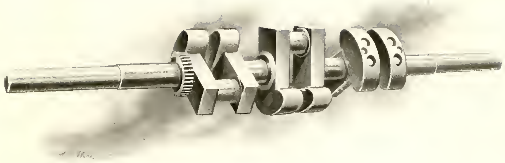
Separate oil cups are used to lubricate the main bearings, all the oil of which is saved by allowing it to drain into the crank case and replenish that lost by evaporation.

CONNECTING RODS.

The connecting rods are of the simple marine type, rectangular in cross section and provided with adjustable bearings at both ends.

The connecting rod bolts are of such a length that they dip into the oil in the crank case just far enough to submerge the lower nut on each bolt when the crank is in its lower dead center position, this then causes oil to splash over the internal working parts. The upper end of the connecting rod is fitted with phosphor boxes which have the wedge arrangement for adjustment.

To obtain access to this brown box on an assembled engine, it is necessary to turn the engine over until the piston is in its lowest possible position; then a hole in the wall of the cylinder directly opposite the wedge screw will register exactly with a hole in the side of the cylinder which is closed by means of a screw plug. With this plug removed the wedge bolt and its jam nut are accessible



CRANK SHAFT OF THREE CYLINDER ENGINE

and can be adjusted by means of a socket wrench.

The piston is of the simple trunk type, made of a specially hard cast iron and packed with cast iron spring rings. It is very long so that the side thrust of the connecting rod is dissipated without causing any considerable friction.

CRANK SHAFT.

The crank shaft is built up; each crank pin with its two cheeks constituting one part. It is of sufficient strength, as its diameter and that of the crank pin are made to exceed one half the cylinder diameter.

Permanently connected to the main shaft is a gear which meshes with other gears and drives the valve mechanism.

VALVES.

The valves are of the mushroom or poppet type, two being required for each cylinder, one inlet and one exhaust. They both operate vertically, the inlet valve by means of a rod and lever, and the exhaust by means of a vertical rod. The motion of the cam on the inlet can shaft is transmitted to the valve thru

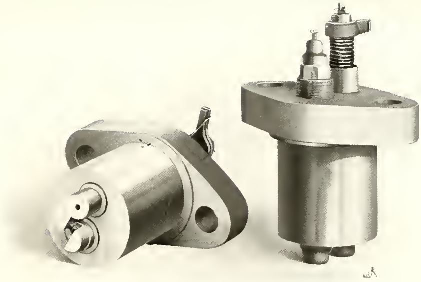


Fig. 10. Igniter

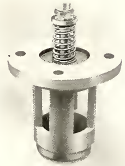


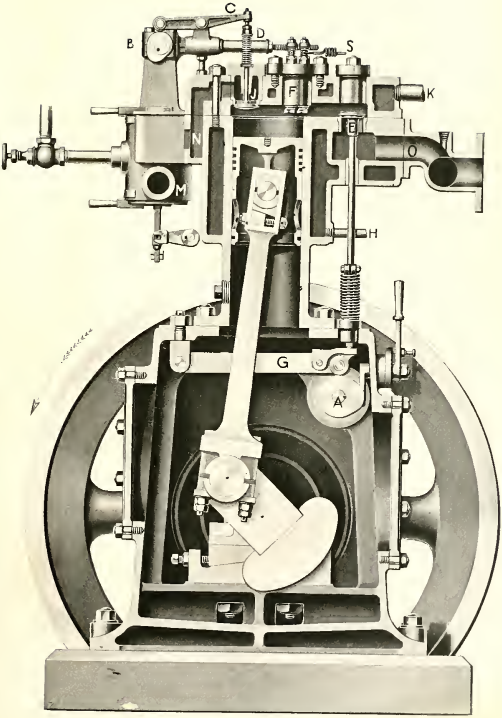
Fig. 9. Admission Valve

a lever, one end of which contains a roller which is in contact with the cam, the other end of which operates a vertical stem, to which is attached the valve. The valve is always held up against its seat by means of a spring, excepting when the lever arm forces it down to allow the admission of a new charge. The principle of operation of the exhaust valve is practically the same but instead of opening downward, it opens by raising the valve upward.

Each exhaust cam works against a roller carried on the free end of the guide lever. Projecting downward from the exhaust valve is a long stem which rests on the upper side of the guide lever; a spring being used to hold the exhaust valve to its seat and the valve stem in contact with the guide lever. Both valves can be readily removed for regrinding without disturbing any of the main parts of the engine.

IGNITION.

The ignition is of the hammer break type. It is a removable plug fitting in the cylinder head, being bolted to the top of the cylinder thru a projecting flange. It has two poles, one stationary



Cross Section through Cylinder

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and the other movable. To the stationary pole is attached the wire which conducts the electric current.

At the end of the movable pole is a short lever which is moved by a collar on the end of the horizontal plunger marked (D", in Fig.) and breaks an electric circuit. This interruption of current at the proper moment, causes an electrical discharge across the opening of the circuit, the heat from which causes combustion.

The igniter mechanism is so arranged that the current is interrupted only at the beginning of each power stroke. The current for the igniter is furnished by a storage battery.

FIG. (CROSS SECTION THRU CYLINDER)

Referring to the sectional cut thru the cylinder, the shaft marked "A" represents the exhaust cam shaft. It is driven by gears from the main shaft. Since the valves for each cylinder have to perform their function only once for every two revolutions of the crank, the comparative motion of cam to crank shaft must be reduced to one half and consequently a train of gears is used to make the required reduction in speed. The arm lettered "G" is a guide lever having a roller at

one end, against which the exhaust cam works.

The exhaust valve "E" has a long stem projecting downward and resting on the guide lever. The spring attached to it holds the valve to its seat and the stem in contact with the lever.

Leading from the exhaust cam shaft to the opposite side of the engine is a horizontal shaft with bevel gears, engaging with a vertical shaft, which in turn drives the inlet cam shaft "B". To this vertical shaft is attached the governor.

Attached to the cam shaft are six cams, two for each cylinder. One engages against a roller which is on the end of the horizontal lever arm "C". As the throw side of the cam comes up the other end of the lever arm depresses the inlet valve stem, thus opening the valve for admission of the mixture of gas and air. A spring attached to the valve stem serves to hold the valve against its seat and also to keep the cam and roller in contact with each other.

Adjacent to the inlet valve cam is the igniter cam, which operates the horizontal plunger "D". At the ebd of this plunger is a collar which moves a short lever on the movable pole of the igniter. The other

and is squared and is held against the cam by a spring. At the point of ignition is a straight drop of about 1/4" in the cam. To prevent any damage in case the engine is turned backwards, the cam is provided with a rachet, so that it only operates when the engine is turned forward. The cam is loose on the shaft, but is fastened by means of its hub to a collar which is fitted on to the shaft. On one end of the hub and on the collar are 100 little teeth which mesh with each other. By loosening the screws which hold the cam against the collar, the cam can be moved forward or backward, thus making an earlier or later ignition, each tooth representing nearly 3 degrees change in the ignition.

The upper portions of the cylinders are water jacketed as shown in the cut, water entering at "H" and discharging at "K".

The part lettered "O" is the passage way for the exhaust gases; "M" the mixing valve chamber; and "N" the port leading to the inlet valve "J"

REGULATION.

Attached to the vertical spindle which is geared to the main engine shaft is the governor, which

is of the ordinary fly ball type. The motion of the governor is transmitted to the regulating valve thru a rocker shaft and levers. Slight changes in speed due to changes in load on the engine, cause a rise and fall of the governor sleeve, which when transmitted to the mixing valve regulates the quantity of mixture admitted to the cylinders.

The mixing chamber consists of a cylindrical valve surrounded by two independent sleeves, one above the other, each having ports in them, gas entering the upper one and air thru the lower one.

attached to each sleeve is a lever which moves over a graduated arc. When the gas enters at atmospheric pressure, the divisions on the scale indicate the exact proportions of air and gas in the mixture supplied to the cylinders.

Attached to the bottom of the mixing valve are two springs which can be adjusted while the engine is running, so as to alter the position of the governor and consequently make a slight variation in the speed.

INDICATOR ATTACHMENT.

This engine has also a special form of indicator

attachement. Another chain drive from the main crank shaft actuates a small shaft which extends the entire length of the exhaust side of the engine. Attached to this shaft are three eccentrics, one opposite each cylinder, which operate vertical rods. Near the upper extremities of these rods are screwed on small horizontal rods to which are attached the indicator cords.

STARTING.

The engine is always started by means of compressed air. On the end of the inlet cam is a small screw with a milled head, which when screwed in tight makes the inlet cam inoperative and consequently prevents any gas from entering cylinder. At the rear of the engine are three levers which project thru the crank case. By moving the right lever to the right as far as it will go, the regular exhaust cam is thrown out and a supplementary cam, which keeps the exhaust valve open during every up stroke of the piston instead of every other stroke as when the engine is in full operation, is thrown in. By moving the other two levers to the left as fas a possible, each one throws a collar against its exhaust cam, so that the throws

roller which is wider than the cam rides on both and opens the exhaust during each up stroke. This **is** done to avoid compression.

At the side of the engine next to the cylinder which can be made inoperative with gas, is attached a starting valve and a check valve. The check valve is actuated by a cam which is attached to the end of the exhaust cam shaft, where it projects thru the end of the crank case. This valve is timed so that it opens each time the piston begins its downward stroke.

To start the engine, it is first necessary to open the check valve, throw the inlet cam out, regulate the supply of air and gas, and set the crank, corresponding to the inoperative cylinder, a little past its dead center. The starting valve is then opened and the engine continues to run on compressed air, until explosion takes place in the other cylinders. The air supply is then shut off and the inlet and exhaust valves are put in thier original working condition. The engine is then in full operation. To disengage the atarting valve from its cam, it is only necessary to pull upon its stem and turn it a quarter of a revolution.

Illuminating gas was used in making tests. It was received at the engine from the city mains thru a meter and a pressure regulator of the diaphragm type, thus reducing its pressure and allowing it to enter the engine at atmospheric pressure.

Before starting with the tests the clearance volumes of all the cylinders were found and the events were all adjusted to agree with the manufactures best settings.

	Left cylinder.	Mid. Cyl.	Right Cyl.
Inlet opens	5 degrees E	6 deg. E	3.2 deg. E
Inlet closes	14.3 " L	13 " L	12 " L
Ignition	27 " E	30 " E	21 " E
Exh. opens	16 " E	12 " E	15 " E
Exh. closes	2.3 " E	1 " L	3 " L
Clearance volume	22.3	22.3	21.8

E early; L late.

The clearance volumes were found in the following manner. The igniter plug was removed, and the engine turned over until the corresponding crank was

very near its upper dead center position, then the clearance space was filled with water, the igniter plug replaced and the indicator cock opened. The engine was then turned until the piston has passed its upper position, forcing out all excess water, and was near the center of its stroke. The height of water was then measured by means of a scale. Knowing the area of the cylinder, the volume of water was calculated.

The dead center positions were found by means of a tramel. The engine was turned over until the piston was very near the end of its stroke, its exact position was observed by means of a scale resting on the piston. A mark was then made on the fly-wheel with the trammel. The engine was then turned again until the crank had passed its dead center and the piston was in the same position as before as indicated on the scale. Another mark was made with the trammel. The by bisecting the distance between these two marks and turning the engine until the mark coincided with the trammel point, the dead center position was obtained.

After obtaining all the dead center positions,

the valves were timed with reference to these points. The opening and closing of the inlet and exhaust ports were found by turning their stems by hand and noting the instant they were seated or cracked off their seat. The distance from these points on the fly-wheel to the dead center positions, then being measured with a steel tape, and knowing the circumference of the fly-wheel, the timing of events with reference to degrees was calculated.

The point of ignition was located by the snapping of the plunger against the igniter cam and the timing as for the events.

The dead load of the engine as caused by the brake was found by three different methods, all of which agreed within .2 of a lb. By the first method the brake was loosed, the engine turned in one direction and the load on the scales noted; then it was turned in the opposite direction and the load noted. The average of the two gave the dead load. By the second method the brake arm was allowed to drop on the scales from a height of two or three feet, and this also gave the approximate dead load.

The last method of suspending the brake on a

knife edge directly over the center of the shaft was the most accurate.

Calorific determinations of the gas were made by the Junker Calorimeter.

The indicator attachements for each cylinder were tested in the following manner; considering one cylinder indicator, the engine was turned over until the corresponding crank was on its dead center position, then a vertical line was drawn on the paper wrapped around the indicator drum by means of raising the pencil motion. The engine was then turned until the piston was in exactly the same position as before, another vertical line was drawn, these two lines coinciding showed that the motion was in perfect adjustment. Had the two lines not coincided, an adjustment of the eccentric strap on the eccentric would have been necessary.

The engine being in good condition as regards valve settings and ignition settings, the experimental work was begun. A series of tests was run at full load, varying the speed for each run.

Illuminating gas was used throughout all the tests.

The object was to determine the maximum economy of which the engine is capable under the given conditions of speed.

A series of nine tests was made with variations in speed from 110 R.p.m. to 324 R.p.m.

Before taking data for a run, a preliminary test was made in order to find the most economical mixture for the given speed.

The speed was regulated by changing the governor and yoke springs. For variations in speed it is necessary to change the time of ignition for best results. This was done by changing the igniter cams as previously described. It was, however, found that for the lowest speed at which full load could be carried, that is 110 R.p.m., changing the ignition as much as 7 degrees, making it earlier or later, changed the results enough to show an economical test.

The change in ignition for each change of speed was then accomplished by changing the location of the collar on the horizontal plunger that tripped the igniter, sot that the variations were within 3 degrees of crank displacement.

A preliminary test preceded each regular run to obtain the most economical mixture of gas and air. During each run, the mixture of gas and air, and brake load were maintained constant, and the following data were taken: duration of run; cubic feet of gas used; weight of cooling water used; temperatures of inlet and outlet coolingw water; temperature of exhaust gases; temperature of air; temperature of gas; pressure of gas at meter; barometric pressure; and the pressure of gas at engine. The runs were all of short duration, as it was possible to obtain exactly constant conditions for a short time better than for a long period of time.

Having completed the series of tests, the apparatus used was calibrated, such as thermometers and scales, and corrections made in the results before tabulating them.

Indicator cards were taken during each run, but they were not used as a means of computing the indicated horse power. The cards were of value, however, in showing the exact performance in the cylinder and the relative amount of work done in each cylinder.

COMPUTATION OF RESULTS.

$$\text{Brake Horse Power} \qquad \frac{2\ \text{pi}\ r\ n\ p}{33{,}000}$$

r radius of brake arm 5' - 3.25"

n revolutions per minute

pi 3.1416

p net brake load 107.5 #

Explosions per minute 3/2 x R.p.m. as an explosion takes place in each of the three cylinders every other revolution.

Total calorific value of the gas as determined by

$$\text{Junker Calorimeter} \qquad \frac{\text{lbs. of water} \times \text{deg. C.} \times 1.8}{\text{cubic feet of gas burned} \times k}$$

1.8 factor changing degrees centigrade to Fahrenheit Degrees.

k factor which reduced gas under actual conditions to standard conditions of 62 deg. F. and 30" Hg.

Effective heating value Total heating value -

$$\frac{1000 \times \text{lbs. condensed steam}}{\text{cu. ft. gas burned} \times k}$$

Thermodynamic Efficiency B.h.p. in

$$\frac{2545}{\text{B.t.u. B.H.P. Hour}}$$

$$\text{B.t.u. B.H.P. Hour} \quad \frac{\text{Gas Hours x Effective H. Value}}{\text{B.H.P.}}$$

at 62 deg. F and 30" Hg.

From the data obtained in making the tests the following curves were plotted with B.H.P. as abscissa: the cubic feet of gas per B.H.P.; Thermodynamic efficiency per B.H.P.; and the B.t.u. per B.h.p. per hr.

The relationship between speed in R.p.m. and cubic feet of gas per B.h.p. was also plotted. With increase of speed from 110 R.p.m. up to 260 R.p.m. the gas consumption per B.h.p. decreased from 18.32 cu.ft. per B.h.p. to 16.61 cubic feet per B.h.p.; from 260 R.p.m. up to 324 R.p.m. the gas consumption increased gradually up to 17.48 cubic feet per B.h.p.

The cubic feet of gas per B.h.p. and B.t.u. per B.h.p. per hour plotted against B.h.p. gave curves very similar in character to the economy curve. This is evident from the fact that the B.h.p. is a direct function of the R.p.m.

The Thermodynamic efficiency per B.h.p. plotted

against B.h.p. gave a curve which showed an increase in efficiency from 22.17% at the lowest B.h.p. of 11.87 to 24.43 % corresponding to the B.h.p. of 28.11. From this point there is a gradual decrease in the efficiency and finally at the highest B.h.p. obtained which was 35 B.h.p., the corresponding efficiency was found to be 23.14 %.

Other curves were plotted showing the relationship between B.h.p. and cubic feet of gas per hour; cubic feet of air per hour, and speed in R.p.m.

The speed curve plotted against B.h.p., is a straight line as the one is a direct function of the other. The relationship between B.h.p. and cubic ft. of gas and air per hour, remained practically constant throughout all the tests.

RUNNING LOG OF TESTS ON 8x10 WESTINGHOUSE GAS ENGINE.

Run No.	1	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9
Date	May14	May14	May14	May14	May6	May6	May12	May12	May7	May7	May8	May8	May15	May15	May12	May1
Time	11AM	1PM	3-10	3-20	1-25	1-35	11-15	11-25	11-15	11-30	3-25	3-35	4PM	4-15	1PM	1-15
Duration of test seconds	80	354	102	102	432	450	325	330	150	149	130	130	115	115	221	223
Gas consumed cu. ft.	5	30	10	10	48	50	40	40	20	20	20	20	20	20	40	40
Jacket water lbs.	64	290	52	51	320	338	192	195	109	108.5	77	76	58	53	161	159
Barometer " Hg.	29.46	29.46	29.46	29.46	29.4	29.4	29.37	29.37	29.56	29.56	29.56	29.56	29.5	29.5	29.37	29.37
R.P.M.	110	155	183	184	208	210	233	233	260	261	290	292	318	318	324	324
Explosions per minute	165	232	274	276	312	315	349	349	390	391	435	438	477	477	486	486
Temp. Inlet jacket water	47	47	46	47	46	46	46	46	45	45	46	46	46	46.5	46	46
" Outlet " "	71	76	97	96	82	83	89	95	85	84	92	103	114	121	97	102.
" Gas at meter	70	68	72	72	74	72.5	73	73	70	70	73	73	79	79	72	72
" Air at engine	69	69	69	69	76	74.5	75	75	78	78	79.5	79.5	85	85	77.5	79
" Exhaust gases	620	620	620	620	650	650	680	680	720	730	780	780	800	805	810	820
Gas pressure at meter "H_2O.	2.1	2.1	2.1	2.1	1.7	1.5	1.5	1.5	1.3	1.2	1.4	1.5	1.1	1.1	.4	.45
" " " engine "	0	0	0	0	.5	.5	.4	.4	1.	1.	1.	1.	1.	1.	1.7	1.6
Brake load lbs.	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5

Run No.	1	2
Date	May 14	May 14
Duration of test seconds	80	354
Gas consumed cu. ft.	5	30
Air " " "	57.2	343
Eff. Cal. Value B.T.U./c.ft.	626	626
Jacket water lbs.	64	290
Gas per hour cu. ft.	225	305
" " " 62 deg. 30" Hg.	217	296
Air " " " " " "	2495	3350
Jacket water per hour lbs.	2875	2950
Barometer " Hg.	29.46	29.46
Gas pressure at meter " H_2O.	2.1	2.1
" " " engine "	0	0
Temp. Inlet jacket water	47	47
" Outlet " "	71	76
" Gas at meter	70	68
" Air at engine	69	69
" Exhaust gases	620	620
R.P.M.	110	155
Explosions per minute	165	232
Total heat per hour B.T.U.	135800	185000
Brake Horse Power	11.87	16.72
Gas per B.H.P. 62 deg 30"Hg.	18.32	17.72
B.T.U. per B.H.P. per hour	11430	11050
Thermo. Eff. per B.H.P. %	22.17	23.02
Heat lost in jacket water %	50.8	46.2
" " by radiation %	27.03	30.78

Run No.	3	3	Average
Date	May 14	May 14	May 14
Duration of test seconds	102	102	102
Gas consumed cu. ft.	10	10	10
Air " " "	114.3	114.3	114.3
Eff. Cal. Value B.T.U./c.ft.	626	626	626
Jacket water lbs.	52	51	51.5
Gas per hour cu. ft.	353	353	353
" " " 62 deg. 30" Hg.	340	341	340.5
Air " " " " " "	4040	4040	4040
Jacket water per hour lbs.	1835	1800	1817.5
Barometer " Hg.	29.46	29.46	29.46
Gas pressure at meter "H_2O.	2.1	2.1	2.1
" " " engine "	0	0	0
Temp. Inlet jacket water	46	47	46.5
" Outlet " "	97	96	96.5
" Gas at meter	72	72	72
" Air at engine	69	69	69
" Exhaust gases	620	620	620
R.P.M.	183	184	183.5
Explosions per minute	274	276	275
Total heat per hour B.T.U.	212400	213200	212800
Brake Horse Power	19.75	19.85	19.80
Gas per B.H.P. 62 deg 30"Hg.	17.23	17.2	17.21
B.T.U. per B.H.P. per hour	10750	10740	10745
Thermo. Eff. per B.H.P. %	23.67	23.7	23.69
Heat lost in jacket water %	44.	41.4	42.7
" " by radiation %	32.33	34.9	33.62

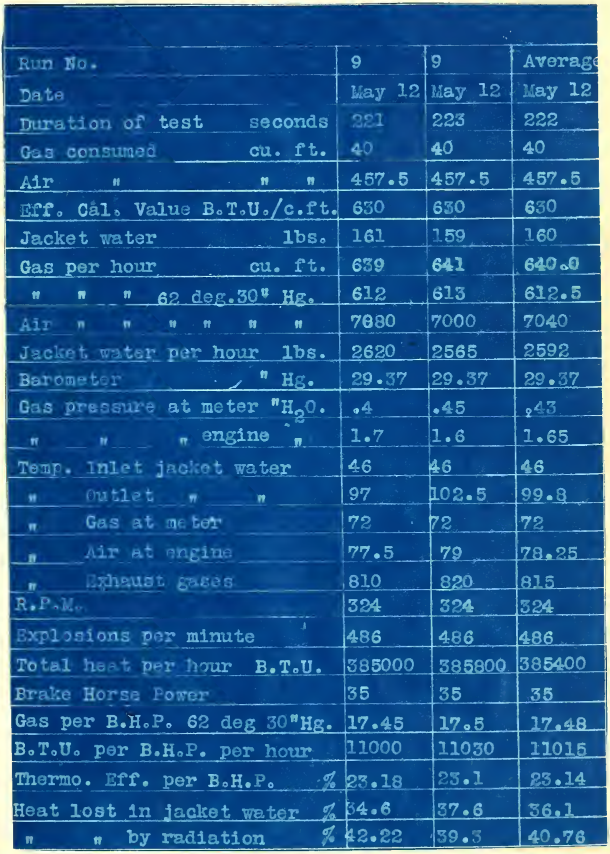
Run No.	4	4	Average
Date	May 6	May 6	May 6
Duration of test seconds	432	450.5	441.3
Gas consumed cu. ft.	48	50	49
Air " " "	549	572	561
Eff. Cal. Value B.T.U./c.ft.	628	628	628
Jacket water lbs.	320	338	329
Gas per hour cu. ft.	400	400	400
" " " 62 deg. 30" Hg.	383	384	383.5
Air " " " " " "	4365	4380	4373
Jacket water per hour lbs.	2665	2700	2683
Barometer " Hg.	29.4	29.4	29.4
Gas pressure at meter " H_2O.	1.7	1.5	1.6
" " " engine "	.5	.5	.5
Temp. Inlet Jacket Water	46	46	46
" Outlet " "	82	83	82.5
" Gas at meter	74	72.5	73.3
" Air at engine	76	74.5	75.3
" Exhaust gases	650	650	650
R.P.M.	208	210	209
Explosions per minute	312	315	314
Total heat per hour B.T.U.	240300	241000	240650
Brake Horse Power	22.4	22.65	22.53
Gas per B.H.P. 62 deg 30"Hg.	17.08	16.94	17.01
B.T.U. per B.H.P. per hour	10720	10630	10675
Thermo. Eff. per B.H.P. %	23.7	23.93	23.82
Heat lost in jacket water %	39.9	41.4	40.7
" " by radiation %	36.4	34.67	36.54

Run No.	5	5	Average
Date	May 12	May 12	May 12
Duration of test seconds	525	530	527.5
Gas consumed cu. ft.	40	40	40
Air " " "	457.5	457.5	457.5
Eff. cal. value B.T.U./c.ft.	630	630	630
Jacket water lbs.	192	195	193.5
Gas per hour cu. ft.	443	436	439.5
" " " 62 deg. 30" Hg.	424	417	420.5
Air " " " " " "	4835	4775	4805
Jacket water per hour lbs.	2125	2125	2125
Barometer " Hg.	29.37	29.37	29.37
Gas pressure at meter "H_2O.	1.5	1.5	1.5
" " " engine "	.4	.4	.4
Temp. Inlet jacket water	46	46	46
" Outlet " "	89	95	92
" Gas at meter	73	73	73
" Air at engine	75	75	75
" Exhaust gases	680	680	680
R.P.M.	233	233	233
Explosions per minute	349	349	349
Total heat per hour B.T.U.	267000	262300	264700
Brake Horse Power	25.15	25.15	25.15
Gas per B.H.P. 62 deg 30" Hg.	16.87	16.6	16.74
B.T.U. per B.H.P. per hour	10620	10430	10525
Thermo. Eff. per B.H.P. %	23.97	24.4	24.19
Heat lost in jacket water %	34.3	39.8	37.1
" " by radiation %	41.73	35.8	37.05

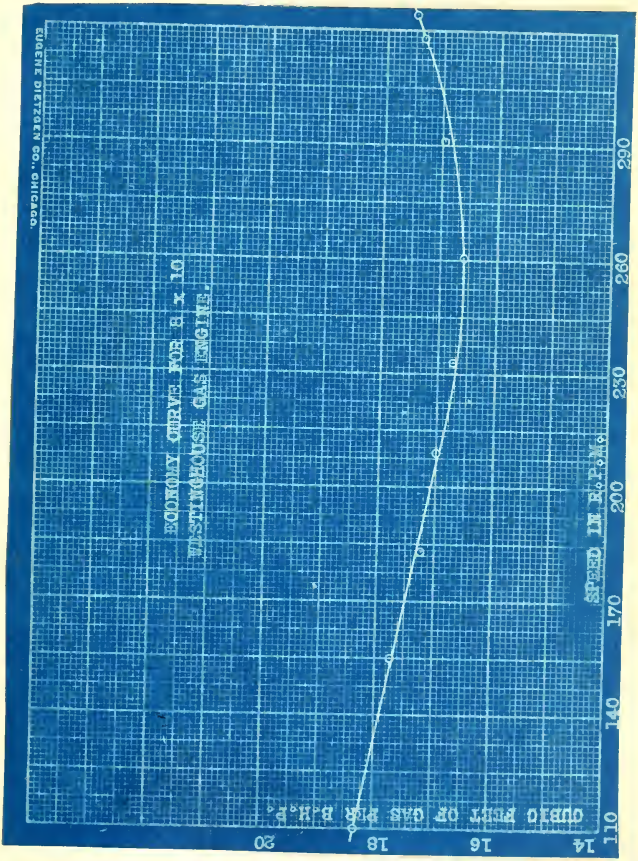
Run No.	6	6	Average
Date	May 7	May 7	May 7
Duration of test seconds	150	149	149.5
Gas consumed cu. ft.	20	20	20
Air " " "	229	229	229
Eff. Cal. Value B.T.U./c.ft.	628	628	628
Jacket water lbs.	109	108.5	108.75
Gas per hour cu. ft.	481	484	482.5
" " " 62 deg.30" Hg.	465	467.5	466.3
Air " " " " " "	5250	5285	5268
Jacket water per hour lbs.	2620	2620	2620
Barometer " Hg.	29.56	29.56	29.56
Gas pressure at meter "H_2O.	1.3	1.2	1.25
" " " engine "	1.	1.	1.
Temp. Inlet jacket water	45	45	45
" Outlet " "	85	84	84.5
" Gas at meter	70	70	70
" Air at engine	78	78	78
" Exhaust gases	720	730	725
R.P.M.	260	261	260.5
Explosions per minute	390	391	390.5
Total heat per hour B.T.U.	292000	293600	292800
Brake Horse Power	28.04	28.18	28.11
Gas per B.H.P. 62 deg 30"Hg.	16.6	16.62	16.61
B.T.U. per B.H.P. per hour	10400	10420	10410
Thermo. Eff. per B.H.P. %	24.45	24.4	24.43
Heat lost in jacket water %	35.8	34.7	35.25
" " by radiation %	39.75	40.9	40.43

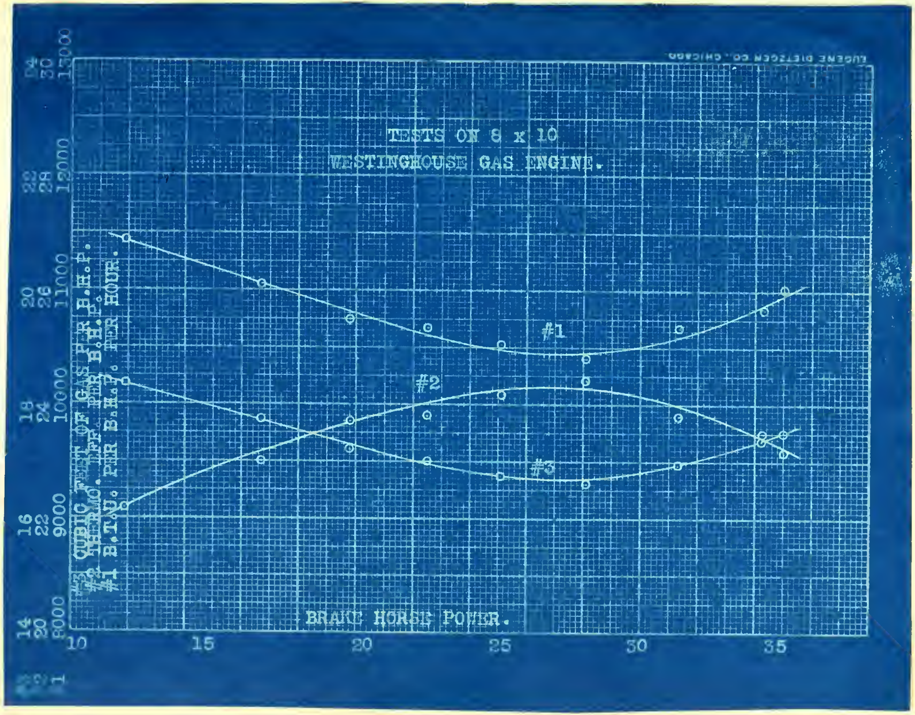
Run No.	7	7	Average
Date	May 8	May 8	May 8
Duration of test seconds	130	130	130
Gas consumed cu. ft.	20	20	20
Air " " "	229	229	229
Eff. Cal. Value B.T.U./c.ft.	628	628	628
Jacket water lbs.	77	76	76.5
Gas per hour cu. ft.	554	554	554
" " " 62 deg.30" Hg.	534	534	534
Air " " " " " "	6035	6035	6035
Jacket water per hour lbs.	2130	2100	2115
Barometer " Hg.	29.56	29.56	29.56
Gas pressureat meter " H_2O.	1.4	1.5	1.45
" " " engine "	1.	1.	1.
Temp. Inlet jacket water	46	46	46
" Outlet " "	92	103	97.5
" Gas at meter	73	73	73
" Air at engine	79.5	79.5	79.5
" Exhaust gases	780	780	780
R.P.M.	290	292	291
Explosions per minute	435	438	437
Total heat per hour B.T.U.	335300	335300	335300
Brake Horse Power	31.25	31.48	31.37
Gas per B.H.P. 62 deg 30"Hg.	17.03	16.92	16.98
B.T.U. per B.H.P. per hour	10710	10640	10675
Thermo. Eff. per B.H.P. %	23.7	23.9	23.8
Heat lost in jacket water %	29.3	35.8	32.3
" " by radiation %	47.	40.3	43.65

Run No.	8	8	Average
Date	May 15	May 15	May 15
Duration of test seconds	115	115	115
Gas consumed cu. ft.	20	20	20
Air " " "	229	229	229
Eff. Cal. Value B.T.U./c.ft.	625	625	625
Jacket water lbs.	58	53	55.5
Gas per hour cu. ft.	626	626	626
" " " 62deg. 30" Hg.	596	596	596
Air " " " " " "	6760	6760	6760
Jacket water per hour lbs.	1805	1663	1734
Barometer " Hg.	29.5	29.5	29.5
Gas pressure at meter "H_2O.	1.1	1.1	1.1
" " " engine "	1.	1.	1.
Temp. Inlet jacket water	46	46.5	46
" Outlet " "	114	121	118
" Gas at meter	79	79	79
" Air at engine	85	85	85
" Exhaust gases	800	805	803
R.P.M.	318	318	318
Explosions per minute	477	477	477
Total heat per hour B.T.U.	372000	372000	372000
Brake Horse Power	34.3	34.3	34.3
Gas per B.H.P. 62 deg 30"Hg.	17.35	17.35	17.35
B.T.U. per B.H.P. per hour	10840	10840	10840
Thermo. Eff. per B.H.P. %	23.5	23.5	23.5
Heat lost in jacket water %	33.	33.3	33.15
" " by radiation %	43.5	43.2	43.35

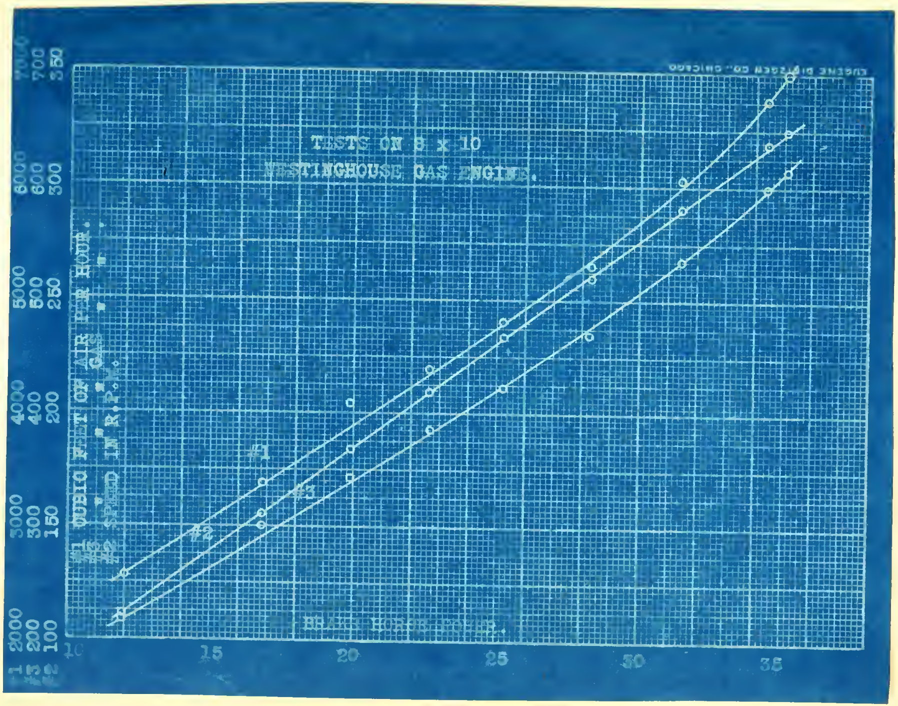


Run No.	9	9	Averag
Date	May 12	May 12	May 12
Duration of test seconds	221	223	222
Gas consumed cu. ft.	40	40	40
Air " " "	457.5	457.5	457.5
Eff. Cal. Value B.T.U./c.ft.	630	630	630
Jacket water lbs.	161	159	160
Gas per hour cu. ft.	639	641	640.0
" " " 62 deg.30" Hg.	612	613	612.5
Air " " " " " "	7080	7000	7040
Jacket water per hour lbs.	2620	2565	2592
Barometer " Hg.	29.37	29.37	29.37
Gas pressure at meter "H_2O.	.4	.45	.43
" " " engine "	1.7	1.6	1.65
Temp. Inlet jacket water	46	46	46
" Outlet " "	97	102.5	99.8
" Gas at meter	72	72	72
" Air at engine	77.5	79	78.25
" Exhaust gases	810	820	815
R.P.M.	324	324	324
Explosions per minute	486	486	486
Total heat per hour B.T.U.	385000	385800	385400
Brake Horse Power	35	35	35
Gas per B.H.P. 62 deg 30"Hg.	17.45	17.5	17.48
B.T.U. per B.H.P. per hour	11000	11030	11015
Thermo. Eff. per B.H.P. %	23.18	23.1	23.14
Heat lost in jacket water %	34.6	37.6	36.1
" " by radiation %	42.22	39.3	40.76


ECONOMY CURVE FOR 8 x 10
WESTINGHOUSE GAS ENGINE.
SPEED IN R.P.M.
110
140
170
200
230
260
290
CUBIC FEET OF GAS PER B.H.P.
14
16
18
20
EUGENE DIETZGEN CO., CHICAGO.



TESTS ON 8 x 10
WESTINGHOUSE GAS ENGINE.


TESTS ON 8 x 10
WESTINGHOUSE GAS ENGINE.
#1 CUBIC FEET OF AIR PER HOUR.
#3 " " " GAS " " .
#2 SPEED IN R.P.M.
#1
#2
#3
BRAKE HORSE POWER.
10
15
20
25
30
35
#1 2000 3000 4000 5000 6000 7000
#3 200 300 400 500 600 700
#2 100 150 200 250 300 350
EUGENE DIETZGEN CO., CHICAGO

R.P.M. 110 [illegible] 1
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l = [illegible]
m E P = 92. [illegible]

[illegible] = 2
area = 1.09
length = 2.58
m E P = 91.
= 15 R [illegible]

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m E [illegible] = .92
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length = 2.89
m E = .93
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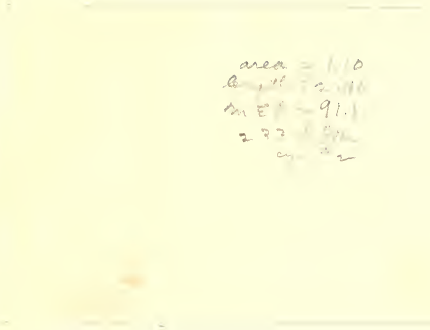

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M E P = 91.1
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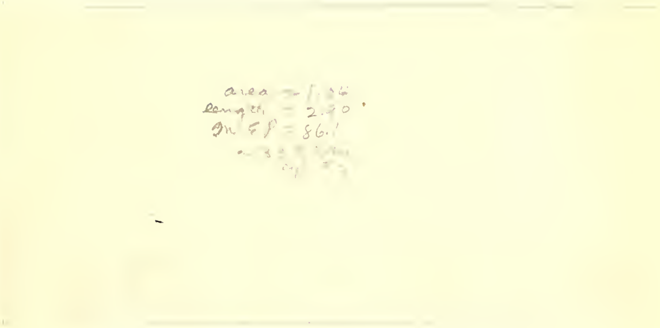
cyl [illegible] 2



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M E P = 86.1
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length = 2.40
m e p = 85.5
233 h.p.
cyl = 2

area = 1.11
length = 2.40
m e p = 91.9
260 h.p.m
cyl I 3

area = 1.09
length = .90
m E P = 89.4
233 R.P.m.
cy #1

cyl # 2
area = 1.13
length = 2.90
m E P = 93.0
290 R P m

May 8
cyl # 2

area = 1.15
length = 2.3
m E P = 95.2
292 R P M

cyl 2
8

cyl # 2

area = 1.22
length = 2.40
m E P = 101.
318 R P M

Cyl 2
8

cyl # 3
area = 1.18
length = 2.00
M E P = 97.8
292 R P M

area = 1.15
length = 2.10
M E P = 95.2
318 R P M
cyl # 1

Full load. Cyl 2
[illegible] 8

area = 1.14
length = 2.0
M E P = 94.3
290 R P M

area = 1.25
length = 2.[illegible]
M E P = 101.[illegible]
324 R P M
[illegible] 2